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(54) **SYSTEM CONTROLLER FOR MONITORING A CHARACTERISTIC SYSTEM ENERGY OF A COMPUTING SYSTEM**

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CPC ***G06F 1/305*** (2013.01)

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CPC G06F 1/3206; G05F 1/10; H02M 1/0003; H02M 3/1582
See application file for complete search history.

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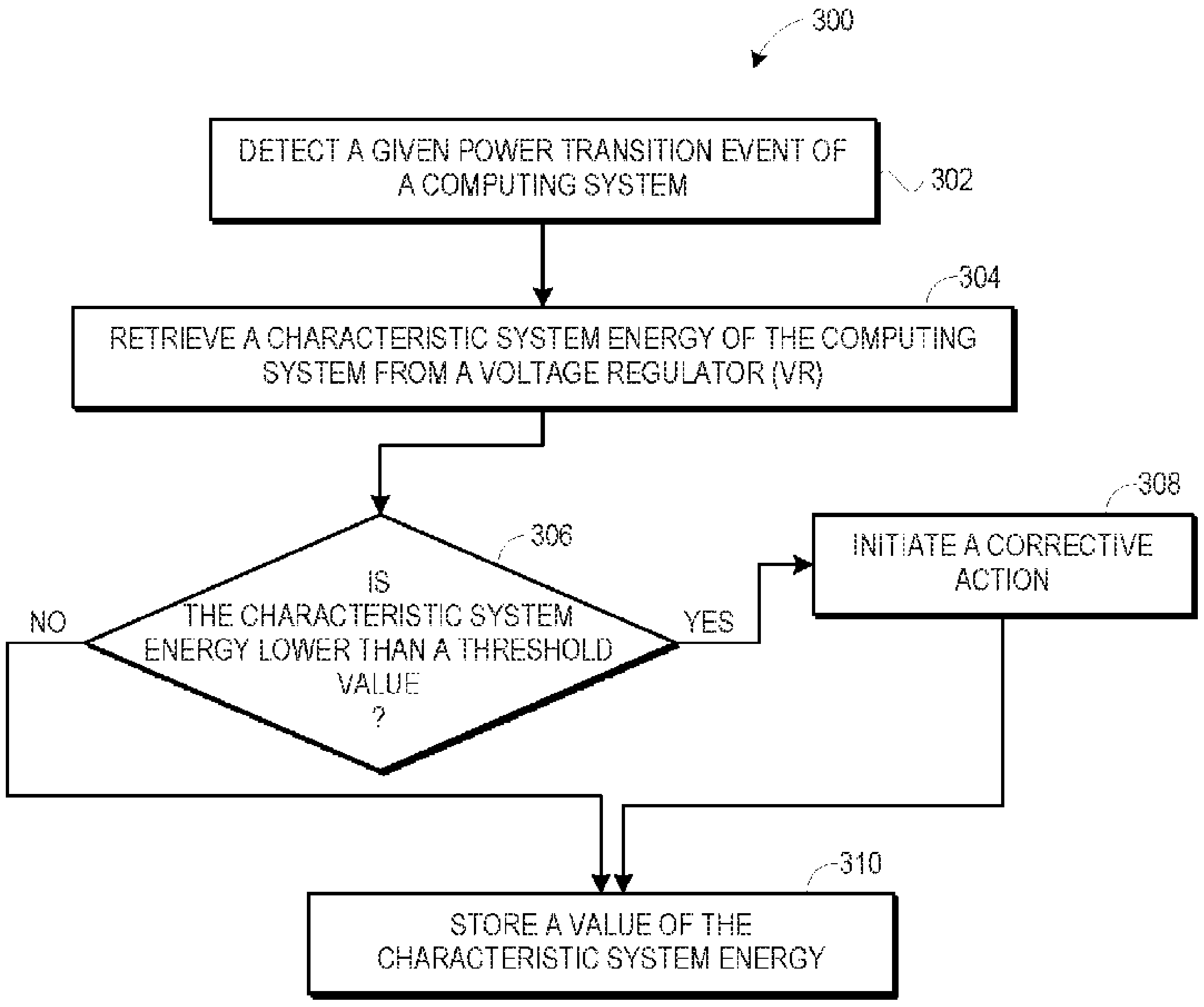
(57) **ABSTRACT**

Examples described herein relate to a system controller for tracking a characteristic system energy of a computing system. The system controller may retrieve the characteristic system energy of the computing system from a voltage regulator (VR). The VR may include a VR controller, one or more phase converters, and an output capacitor coupled to a load to provide an operating voltage to the load. The characteristic system energy is related to a sum of capacitances comprising a capacitance of the output capacitor and a capacitance of the load and is determined by the VR controller based on a voltage at the output capacitor and a charging current or a discharging current of the output capacitor via the one or more phase converters. Further, the system controller may determine whether to initiate a corrective action for the VR based on a comparison between the characteristic system energy and a threshold value.

20 Claims, 7 Drawing Sheets



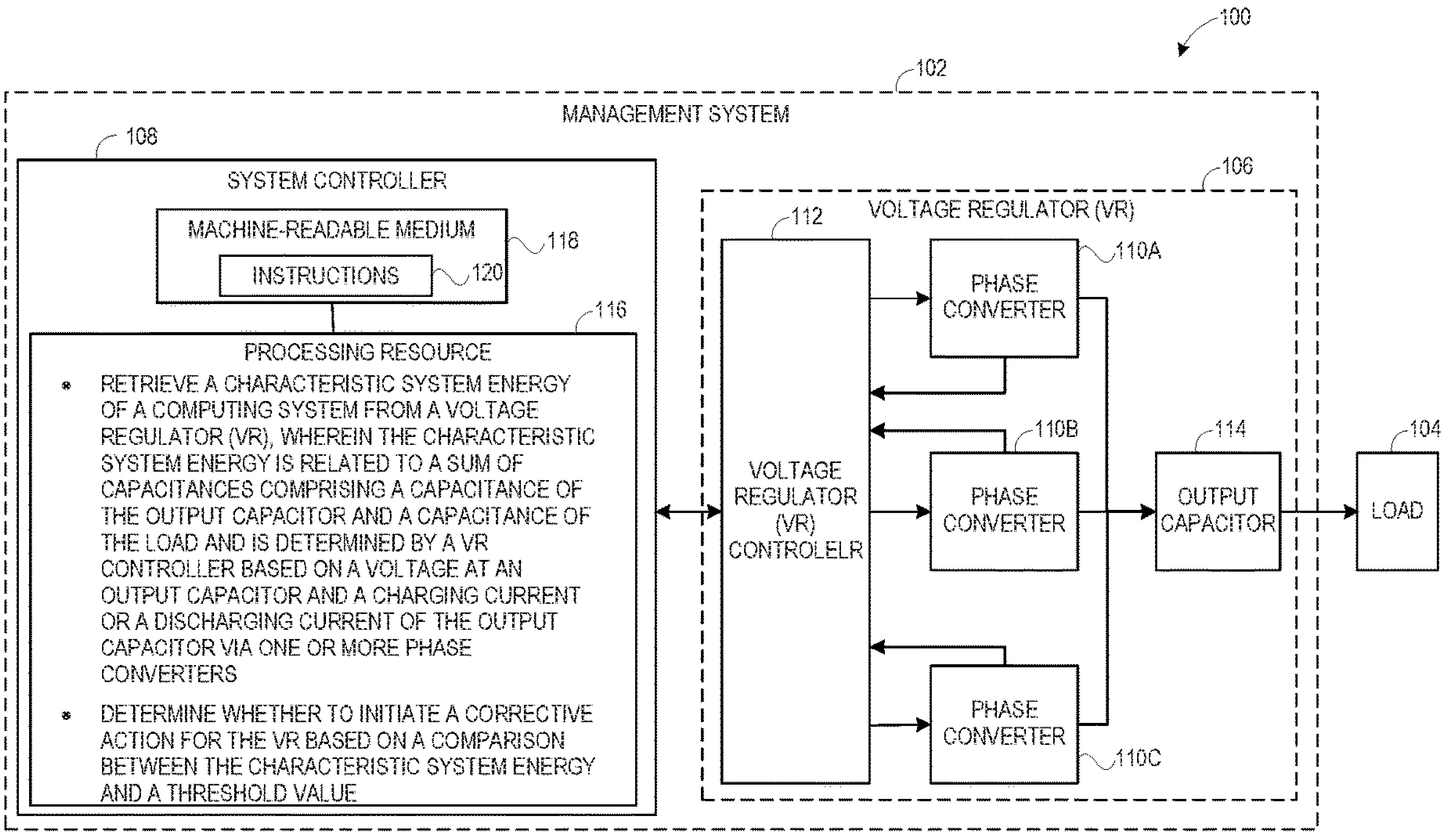

100
102
MANAGEMENT SYSTEM
108
SYSTEM CONTROLLER
MACHINE-READABLE MEDIUM
118
INSTRUCTIONS
120
116
PROCESSING RESOURCE
• RETRIEVE A CHARACTERISTIC SYSTEM ENERGY OF A COMPUTING SYSTEM FROM A VOLTAGE REGULATOR (VR), WHEREIN THE CHARACTERISTIC SYSTEM ENERGY IS RELATED TO A SUM OF CAPACITANCES COMPRISING A CAPACITANCE OF THE OUTPUT CAPACITOR AND A CAPACITANCE OF THE LOAD AND IS DETERMINED BY A VR CONTROLLER BASED ON A VOLTAGE AT AN OUTPUT CAPACITOR AND A CHARGING CURRENT OR A DISCHARGING CURRENT OF THE OUTPUT CAPACITOR VIA ONE OR MORE PHASE CONVERTERS
• DETERMINE WHETHER TO INITIATE A CORRECTIVE ACTION FOR THE VR BASED ON A COMPARISON BETWEEN THE CHARACTERISTIC SYSTEM ENERGY AND A THRESHOLD VALUE
106
VOLTAGE REGULATOR (VR)
112
VOLTAGE REGULATOR (VR) CONTROLELR
PHASE CONVERTER
110A
110B
PHASE CONVERTER
PHASE CONVERTER
110C
114
OUTPUT CAPACITOR
104
LOAD

FIG. 1

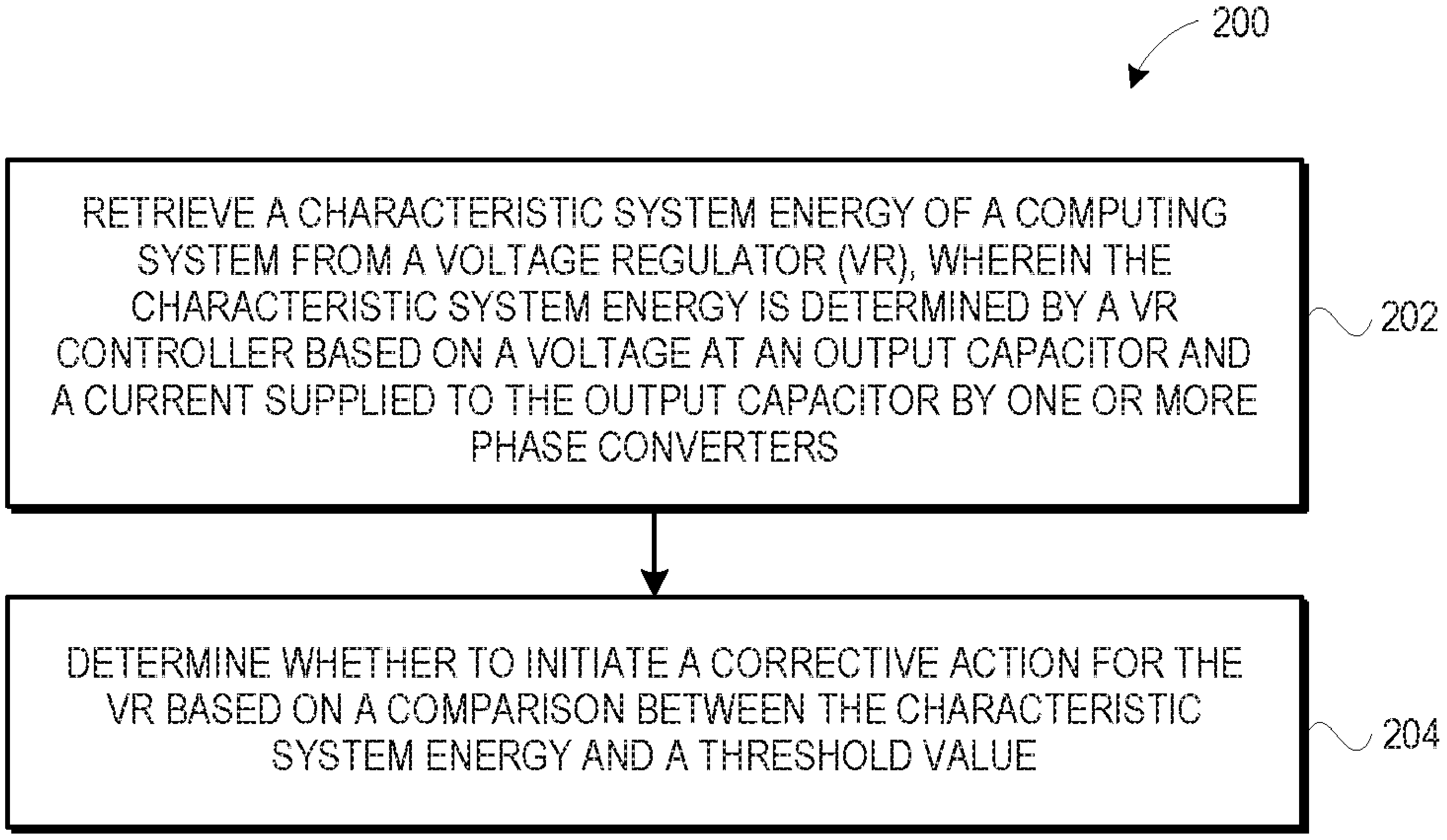

200
RETRIEVE A CHARACTERISTIC SYSTEM ENERGY OF A COMPUTING SYSTEM FROM A VOLTAGE REGULATOR (VR), WHEREIN THE CHARACTERISTIC SYSTEM ENERGY IS DETERMINED BY A VR CONTROLLER BASED ON A VOLTAGE AT AN OUTPUT CAPACITOR AND A CURRENT SUPPLIED TO THE OUTPUT CAPACITOR BY ONE OR MORE PHASE CONVERTERS
202
DETERMINE WHETHER TO INITIATE A CORRECTIVE ACTION FOR THE VR BASED ON A COMPARISON BETWEEN THE CHARACTERISTIC SYSTEM ENERGY AND A THRESHOLD VALUE
204

FIG. 2

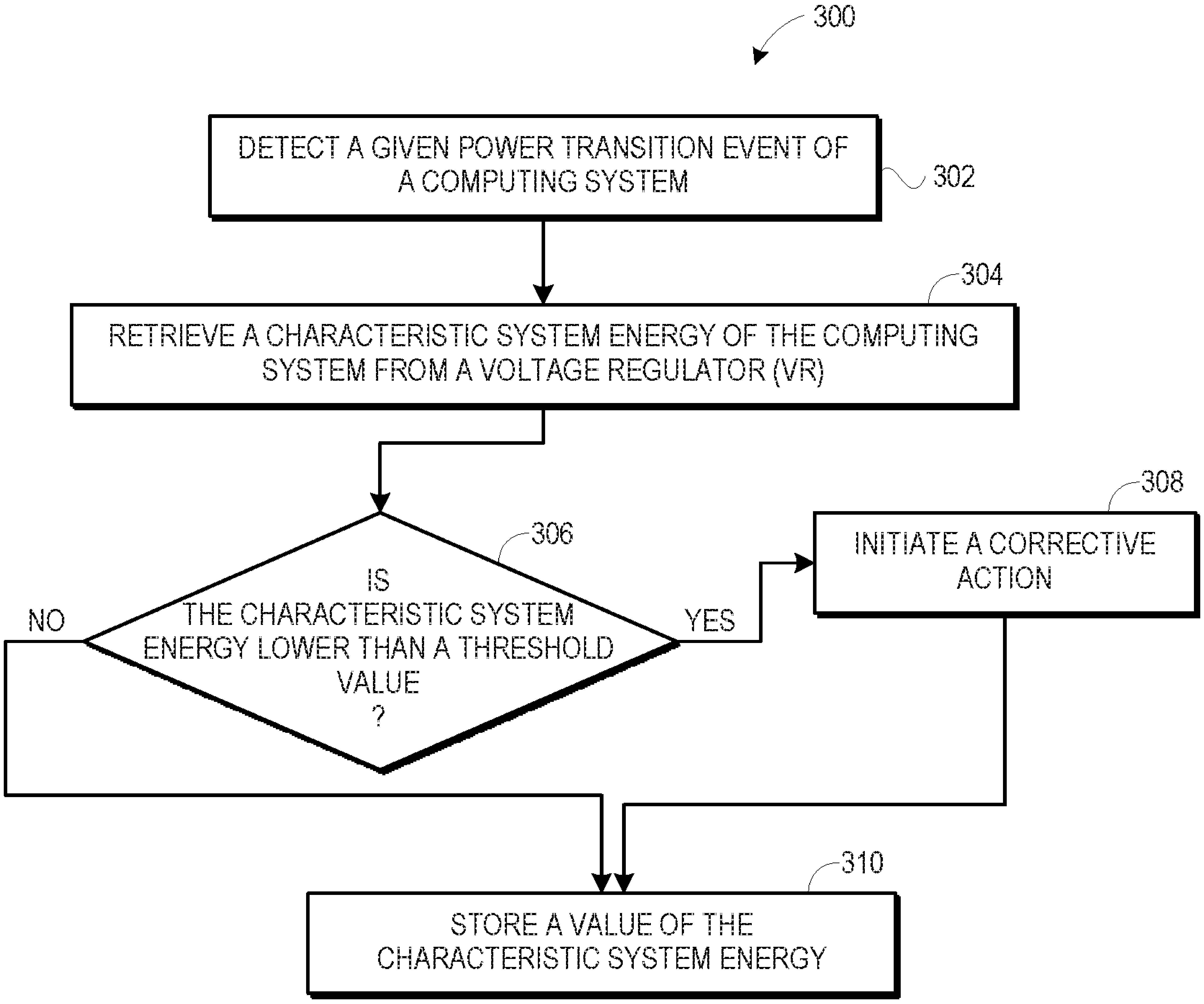

300
DETECT A GIVEN POWER TRANSITION EVENT OF A COMPUTING SYSTEM
302
304
RETRIEVE A CHARACTERISTIC SYSTEM ENERGY OF THE COMPUTING SYSTEM FROM A VOLTAGE REGULATOR (VR)
306
IS THE CHARACTERISTIC SYSTEM ENERGY LOWER THAN A THRESHOLD VALUE ?
NO
YES
308
INITIATE A CORRECTIVE ACTION
310
STORE A VALUE OF THE CHARACTERISTIC SYSTEM ENERGY

FIG. 3

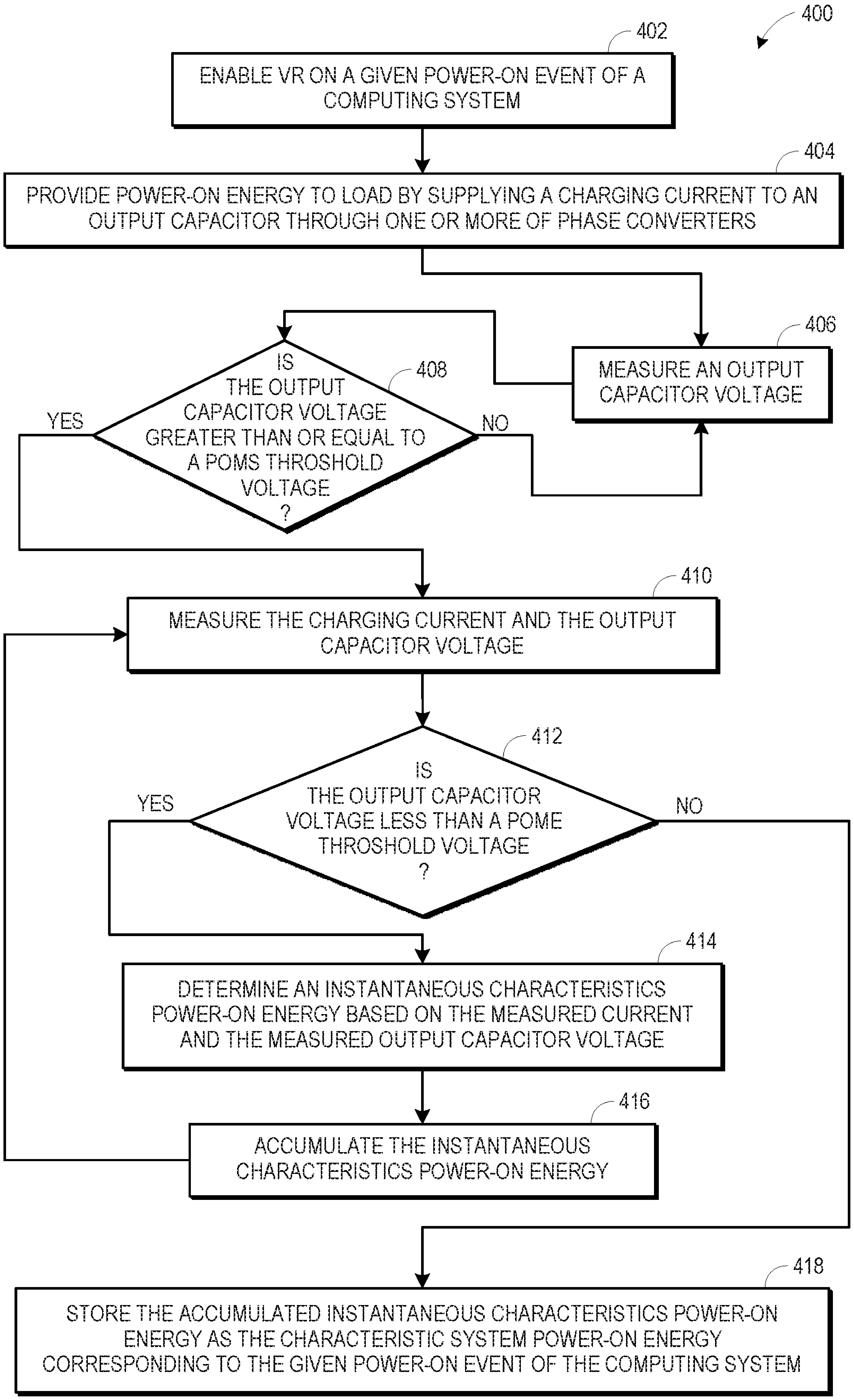

400
402
ENABLE VR ON A GIVEN POWER-ON EVENT OF A COMPUTING SYSTEM
404
PROVIDE POWER-ON ENERGY TO LOAD BY SUPPLYING A CHARGING CURRENT TO AN OUTPUT CAPACITOR THROUGH ONE OR MORE OF PHASE CONVERTERS
406
MEASURE AN OUTPUT CAPACITOR VOLTAGE
408
IS THE OUTPUT CAPACITOR VOLTAGE GREATER THAN OR EQUAL TO A POMS THROSHOLD VOLTAGE ?
YES
NO
410
MEASURE THE CHARGING CURRENT AND THE OUTPUT CAPACITOR VOLTAGE
412
IS THE OUTPUT CAPACITOR VOLTAGE LESS THAN A POME THROSHOLD VOLTAGE ?
YES
NO
414
DETERMINE AN INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY BASED ON THE MEASURED CURRENT AND THE MEASURED OUTPUT CAPACITOR VOLTAGE
416
ACCUMULATE THE INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY
418
STORE THE ACCUMULATED INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY AS THE CHARACTERISTIC SYSTEM POWER-ON ENERGY CORRESPONDING TO THE GIVEN POWER-ON EVENT OF THE COMPUTING SYSTEM

FIG. 4

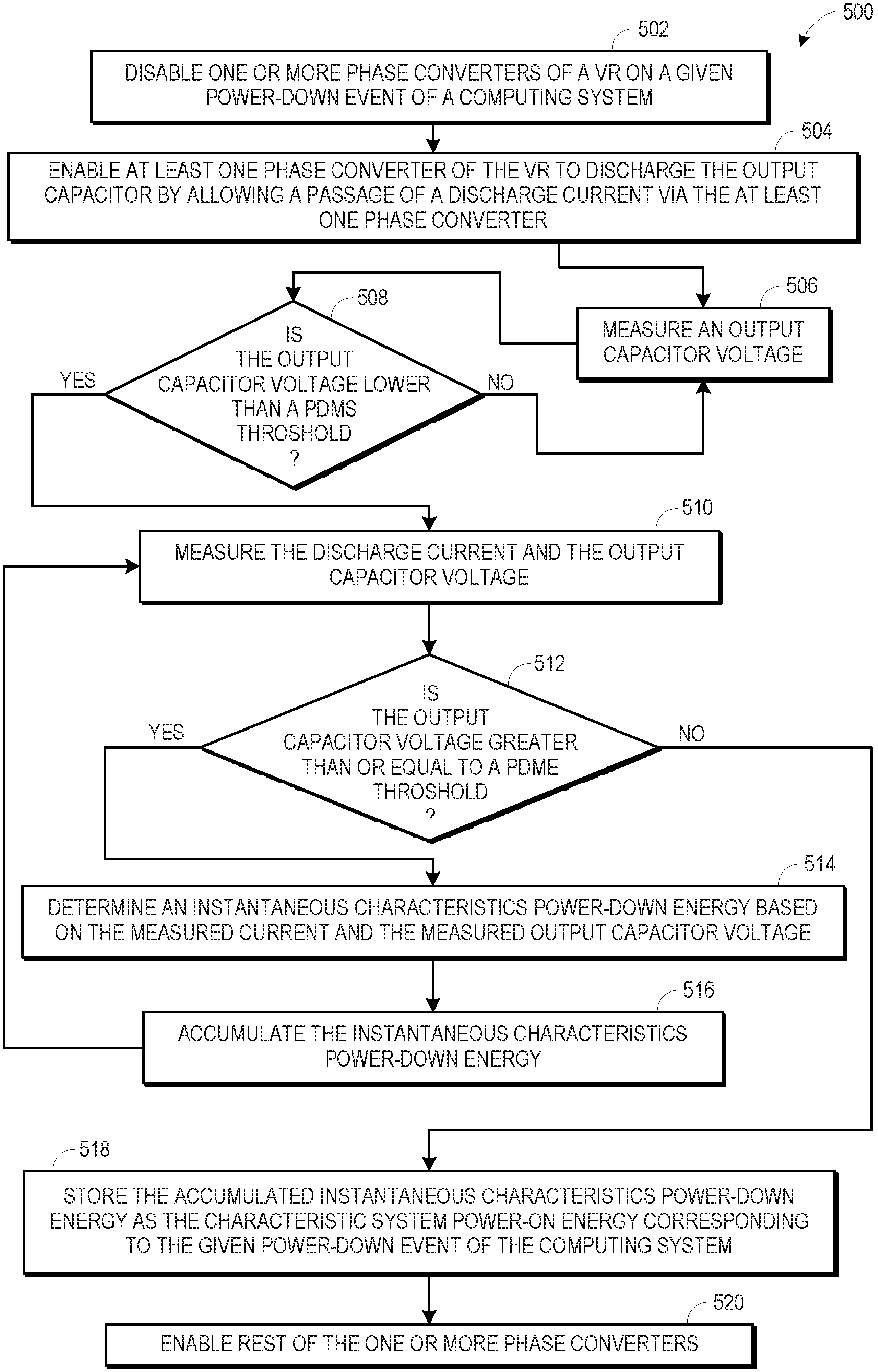

500
502
DISABLE ONE OR MORE PHASE CONVERTERS OF A VR ON A GIVEN POWER-DOWN EVENT OF A COMPUTING SYSTEM
504
ENABLE AT LEAST ONE PHASE CONVERTER OF THE VR TO DISCHARGE THE OUTPUT CAPACITOR BY ALLOWING A PASSAGE OF A DISCHARGE CURRENT VIA THE AT LEAST ONE PHASE CONVERTER
506
MEASURE AN OUTPUT CAPACITOR VOLTAGE
508
IS THE OUTPUT CAPACITOR VOLTAGE LOWER THAN A PDMS THROSHOLD ?
YES
NO
510
MEASURE THE DISCHARGE CURRENT AND THE OUTPUT CAPACITOR VOLTAGE
512
IS THE OUTPUT CAPACITOR VOLTAGE GREATER THAN OR EQUAL TO A PDME THROSHOLD ?
YES
NO
514
DETERMINE AN INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY BASED ON THE MEASURED CURRENT AND THE MEASURED OUTPUT CAPACITOR VOLTAGE
516
ACCUMULATE THE INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY
518
STORE THE ACCUMULATED INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY AS THE CHARACTERISTIC SYSTEM POWER-ON ENERGY CORRESPONDING TO THE GIVEN POWER-DOWN EVENT OF THE COMPUTING SYSTEM
520
ENABLE REST OF THE ONE OR MORE PHASE CONVERTERS

FIG. 5

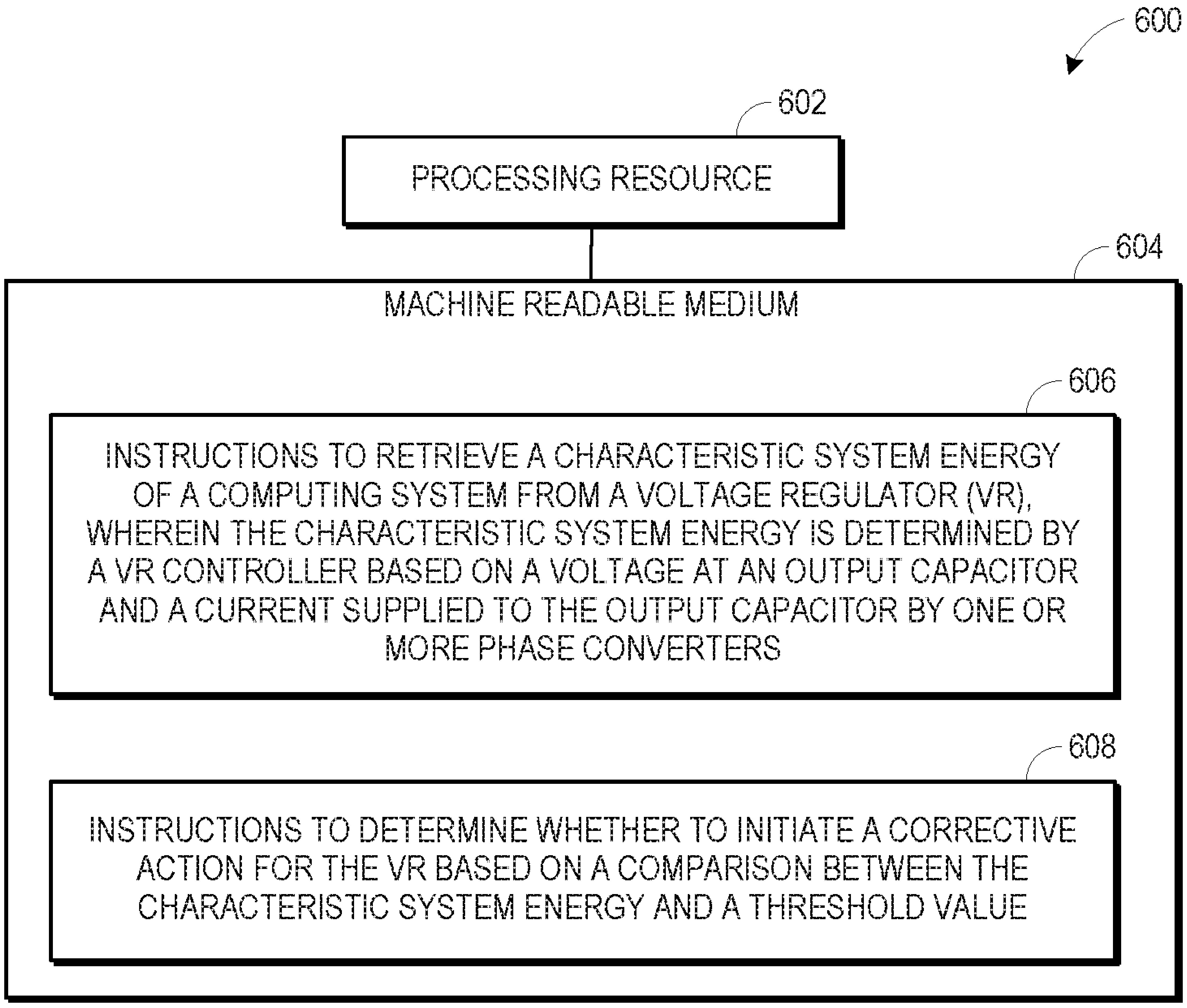

600
602
PROCESSING RESOURCE
604
MACHINE READABLE MEDIUM
606
INSTRUCTIONS TO RETRIEVE A CHARACTERISTIC SYSTEM ENERGY OF A COMPUTING SYSTEM FROM A VOLTAGE REGULATOR (VR), WHEREIN THE CHARACTERISTIC SYSTEM ENERGY IS DETERMINED BY A VR CONTROLLER BASED ON A VOLTAGE AT AN OUTPUT CAPACITOR AND A CURRENT SUPPLIED TO THE OUTPUT CAPACITOR BY ONE OR MORE PHASE CONVERTERS
608
INSTRUCTIONS TO DETERMINE WHETHER TO INITIATE A CORRECTIVE ACTION FOR THE VR BASED ON A COMPARISON BETWEEN THE CHARACTERISTIC SYSTEM ENERGY AND A THRESHOLD VALUE

FIG. 6

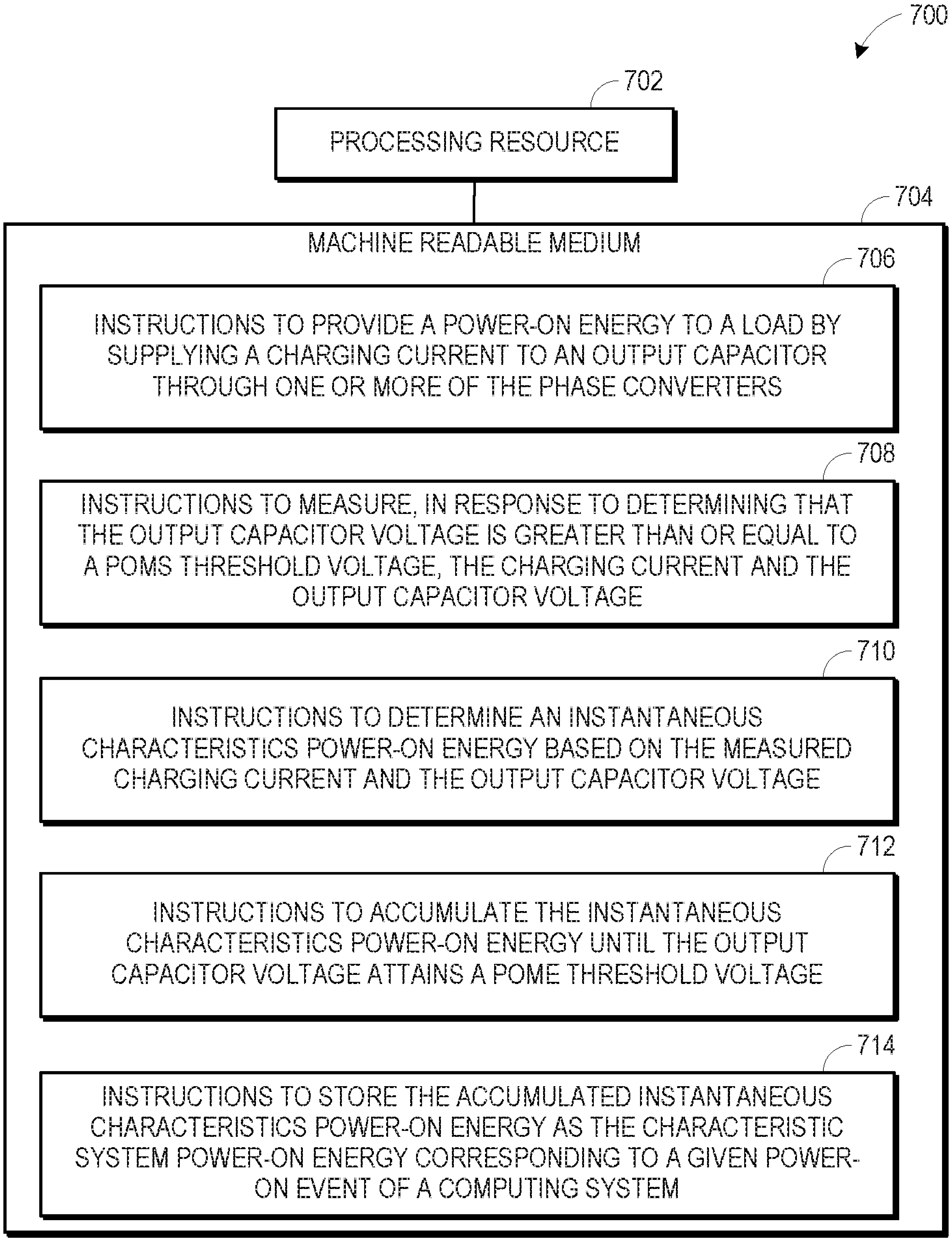

700
702
PROCESSING RESOURCE
704
MACHINE READABLE MEDIUM
706
INSTRUCTIONS TO PROVIDE A POWER-ON ENERGY TO A LOAD BY SUPPLYING A CHARGING CURRENT TO AN OUTPUT CAPACITOR THROUGH ONE OR MORE OF THE PHASE CONVERTERS
708
INSTRUCTIONS TO MEASURE, IN RESPONSE TO DETERMINING THAT THE OUTPUT CAPACITOR VOLTAGE IS GREATER THAN OR EQUAL TO A POMS THRESHOLD VOLTAGE, THE CHARGING CURRENT AND THE OUTPUT CAPACITOR VOLTAGE
710
INSTRUCTIONS TO DETERMINE AN INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY BASED ON THE MEASURED CHARGING CURRENT AND THE OUTPUT CAPACITOR VOLTAGE
712
INSTRUCTIONS TO ACCUMULATE THE INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY UNTIL THE OUTPUT CAPACITOR VOLTAGE ATTAINS A POME THRESHOLD VOLTAGE
714
INSTRUCTIONS TO STORE THE ACCUMULATED INSTANTANEOUS CHARACTERISTICS POWER-ON ENERGY AS THE CHARACTERISTIC SYSTEM POWER-ON ENERGY CORRESPONDING TO A GIVEN POWER-ON EVENT OF A COMPUTING SYSTEM

FIG. 7

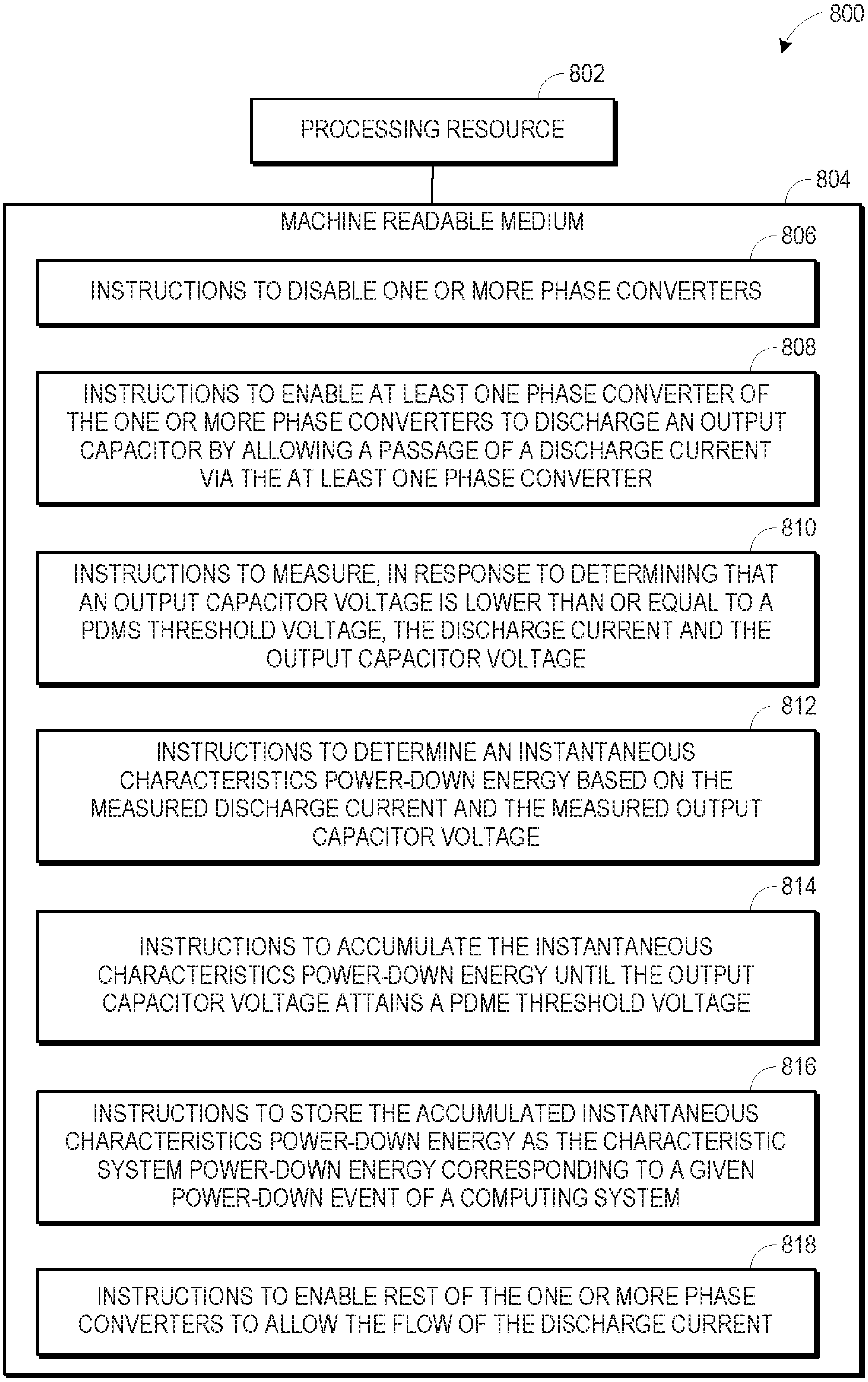

800
802
PROCESSING RESOURCE
804
MACHINE READABLE MEDIUM
806
INSTRUCTIONS TO DISABLE ONE OR MORE PHASE CONVERTERS
808
INSTRUCTIONS TO ENABLE AT LEAST ONE PHASE CONVERTER OF THE ONE OR MORE PHASE CONVERTERS TO DISCHARGE AN OUTPUT CAPACITOR BY ALLOWING A PASSAGE OF A DISCHARGE CURRENT VIA THE AT LEAST ONE PHASE CONVERTER
810
INSTRUCTIONS TO MEASURE, IN RESPONSE TO DETERMINING THAT AN OUTPUT CAPACITOR VOLTAGE IS LOWER THAN OR EQUAL TO A PDMS THRESHOLD VOLTAGE, THE DISCHARGE CURRENT AND THE OUTPUT CAPACITOR VOLTAGE
812
INSTRUCTIONS TO DETERMINE AN INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY BASED ON THE MEASURED DISCHARGE CURRENT AND THE MEASURED OUTPUT CAPACITOR VOLTAGE
814
INSTRUCTIONS TO ACCUMULATE THE INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY UNTIL THE OUTPUT CAPACITOR VOLTAGE ATTAINS A PDME THRESHOLD VOLTAGE
816
INSTRUCTIONS TO STORE THE ACCUMULATED INSTANTANEOUS CHARACTERISTICS POWER-DOWN ENERGY AS THE CHARACTERISTIC SYSTEM POWER-DOWN ENERGY CORRESPONDING TO A GIVEN POWER-DOWN EVENT OF A COMPUTING SYSTEM
818
INSTRUCTIONS TO ENABLE REST OF THE ONE OR MORE PHASE CONVERTERS TO ALLOW THE FLOW OF THE DISCHARGE CURRENT

FIG. 8

SYSTEM CONTROLLER FOR MONITORING A CHARACTERISTIC SYSTEM ENERGY OF A COMPUTING SYSTEM

BACKGROUND

In computing systems, for example, servers, desktop computers, and/or portable computing devices, processing resources (e.g., processors, microprocessors, etc.) are implemented to fulfill various computing demands. The computing demand from the computing systems may vary time-to-time and may be unpredictable in certain instances. Variations in the computing demand may cause changes in a processing load on the processing resources disposed in the computing systems.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present specification will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. **1** depicts a computing system including a management system for tracking a characteristic system energy of a computing system, in accordance with an example;

FIG. **2** is a flow diagram depicting a method for determining whether to take corrective action for a computing system based on a characteristic system energy, in accordance with an example;

FIG. **3** is a flow diagram depicting a method for taking corrective action for a computing system based on a characteristic system energy, in accordance with an example;

FIG. **4** is a flow diagram depicting a method for monitoring a characteristic system energy, in accordance with an example;

FIG. **5** is a flow diagram depicting a method for monitoring a characteristic system energy, in accordance with another example;

FIG. **6** is a block diagram depicting a processing resource and a machine-readable medium encoded with example instructions to determine whether to take a corrective action, in accordance with an example;

FIG. **7** is a block diagram depicting a processing resource and a machine-readable medium encoded with example instructions to monitor a characteristic system energy, in accordance with an example; and

FIG. **8** is a block diagram depicting a processing resource and a machine-readable medium encoded with example instructions to monitor a characteristic system energy, in accordance with an example.

It is emphasized that, in the drawings, various features are not drawn to scale. In fact, in the drawings, the dimensions of the various features have been arbitrarily increased or reduced for clarity of discussion.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. Wherever possible, same reference numbers are used in the drawings and the following description to refer to the same or similar parts. It is to be expressly understood that the drawings are for the purpose of illustration and description only. While several examples are described in this document, modifications, adaptations, and other implementations are possible. Accordingly, the following detailed description does not limit disclosed examples. Instead, the proper scope of the disclosed examples may be defined by the appended claims.

The terminology used herein is for the purpose of describing particular examples and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term "another," as used herein, is defined as at least a second or more. The term "coupled," as used herein, is defined as connected, whether directly without any intervening elements or indirectly with at least one intervening element, unless indicated otherwise. For example, two elements may be coupled mechanically, electrically, or magnetically, or communicatively linked through a communication channel, pathway, network, or system. Further, the term "and/or" as used herein refers to and encompasses any and all possible combinations of the associated listed items. It will also be understood that, although the terms first, second, third, etc. may be used herein to describe various elements, these elements should not be limited by these terms, as these terms are only used to distinguish one element from another unless stated otherwise or the context indicates otherwise. As used herein, the term "includes" means includes but not limited to, the term "including" means including but not limited to. The term "based on" means based at least in part on.

In computing systems, such as, servers, desktop computers, and/or portable computing devices, processing resources are implemented to fulfill various computing demands. The computing demand from these computing systems may vary from time-to-time and may be unpredictable in certain instances. The variations in the computing demand may cause changes in a processing load on the processing resources disposed in the computing systems. For example, a sudden increase in the computing demand may cause an increase, e.g., a surge, in the processing load of the processing resources to address the increased computing demand. Consequently, the processing resources may draw more current to operate at high-performance levels to handle the increased processing load. With use of high-performance processing resources (e.g., processors), peak current demanded by processing resources in the computing system continue to increase from generation to generation.

Typically, in a computing system, processing resources receive regulated power supply. The regulated power may be supplied to the processing resources from a voltage regulator disposed in the computing system. The voltage regulator may typically include power converters having electronic switches, a controller to manage switching of the electronic switches in the power converters, inductors as magnetic storage elements and an output capacitor. The voltage regulator may be coupled to the processing resources via the output capacitor. In an event of the surge in the current drawn by the processing resources, the controller in the voltage regulator may control switching of the electronic switches in the power converters to supply increased current to the processing resources. While the power converters and the controller may take some time to adapt to the change (e.g., sudden increase) in the current demand from the processing resources, the output capacitor may cater to this current demand by quickly discharging an energy stored in the output capacitor. As will be understood, any degradation, lot-to-lot variations, and/or manufacturer-to-manufacturer variations in the capacitance of the output capacitor may lead to situations where the processing resources may be exposed to voltage levels that do not meet minimum processor requirements. This could lead to any number of undesirable consequences (e.g., malfunctioning, untimely shut-down, operating system crash) in the computing system.

In accordance with aspects of the present application, a system controller (e.g., manageability controller/baseboard management controller) in the computing system may track the characteristic system energy of the computing system. For example, the system controller may retrieve the characteristic system energy of the computing system from a voltage regulator (VR) comprising a VR controller, one or more phase converters, and an output capacitor coupled to a load to provide an operating voltage to the load. The characteristic system energy is related to a sum of capacitances comprising a capacitance of the output capacitor and a capacitance of the load and is determined by the VR controller based on a voltage at the output capacitor and a charging current or the discharging current of the output capacitor via the one or more phase converters. In some examples, the VR controller may determine and record the characteristic system energy at a power-on or power-down (e.g., power-off) of the computing system. The term power-down is also interchangeably referred to as power-off. The characteristic system energy recorded by the VR controller may be retrieved by the system controller at every power-on or power-down of the computing system.

Further, the system controller may determine whether to initiate a corrective action (e.g., generating an alert, a service/maintenance request, changing an operating mode of the VR) for the VR based on a comparison between the characteristic system energy and a threshold value. For example, the system controller may determine whether the characteristic system energy is lower than the threshold value, and initiate the corrective action for the VR in response to determining that the characteristic system energy is lower than the threshold value. The characteristic system energy being lower than the threshold value may indicate that the capacitance of the output capacitor of the VR is degraded. An increase in characteristics system energy may indicate processing load current increase during system power-on or power-down characterization.

As will be appreciated, the system controller, in accordance with various aspects of the present disclosure, may track the characteristic system energy that is indicative of a health the output capacitor and/or the load. Accordingly, in some examples, the system controller may aid a manufacturer of the computing system to determine the characteristic system energy and compare it with a corresponding threshold value during production stage of the computing system. The manufacturer may choose to accept the computing system for shipping to a customer based on the comparison of the characteristic system energy with the corresponding threshold value. In addition, the manufacturer may record such measurement of the characteristic system energy of the computing system during production. Moreover, the system controller may aid in tracking the characteristic system energy during an operation of the computing system, as well. The characteristic system energy tracked during the operation of the computing system may aid in taking appropriate corrective action, which may include operating the VR in a different mode, generating a service request, generating an alert, and the like. Additionally, the system controller may also analyze a log of the characteristic system energy measurements tracked over a period to determine a trend of the characteristic system energy for the period. Accordingly, the system controller may determine whether any of the output capacitor of the VR or the load is facing any performance issue for which the corrective action may be initiated. Such tracking of the characteristic system energy may aid in facilitating a reliable operation of the computing system and providing appropriate service and maintenance of the computing system in a timely manner.

Referring now to the drawings, in FIG. **1**, a computing system **100** including a management system **102** for tracking a characteristic system energy of the computing system **100** is presented, in accordance with an example. The computing system **100** may be capable of storing data, processing data, and/or communicating data with external devices over a network. Non-limiting examples of the computing system **100** may include, but are not limited to, a server, a storage device, a network switch, a router, a mobile communication device, a desktop computer, a portable computer, a networked resource enclosure, an edge-computing device, or a WLAN access point. The server may be a blade server, for example. The storage device may be a storage blade, for example.

As depicted in FIG. **1**, the computing system **100** may include the management system **102** coupled to a load **104**. As will be appreciated, the computing system **100** may also include several other electronic components that are not shown in FIG. **1**. The management system **102** may provide a regulated power to the load **104** to enable functioning of the load **104**. The load **104** may be any electronic component that consumes the regulated power generated by the management system **102**. Examples of the load **104** may include storage devices, auxiliary sub-systems, and compute resources such as one or more processors, and the like. In the description hereinafter, the load **104** is described as being a processing resource for illustration purposes. By way of example, the processing resource (i.e., an example load **104**) may be a physical device, for example, one or more central processing unit (CPU), one or more semiconductor-based microprocessors, one or more graphics processing unit (GPU), application-specific integrated circuit (ASIC), a field programmable gate array (FPGA), other hardware devices capable of computing, data processing, and/or graphics processing requirements in the computing system **100**.

The management system **102** may include a voltage regulator (VR) **106** and a system controller **108** operatively coupled to the VR **106**. The management system **102** may supply a regulated power to the load **104**. In some examples, the VR **106** may regulate voltage generated by a power supply (not shown). In some examples, the VR **106** may be connected to the power supply via an input power line. The power supply may receive utility power and convert the utility power to a DC power that may be available on the input power line. Accordingly, the input power line may be generally be maintained at a stable predefined voltage (e.g., 12V DC). In some examples, the VR **106** may further convert the voltage on the input power line to a different voltage level lower than the predefined voltage. For example, if the load **104** operates at a voltage lower than the predefined voltage on the input power line, the VR **106** may generate power at a reduced voltage level suitable for the load **104** to operate and keep the reduced voltage in regulation.

In order to achieve such voltage regulation, the VR **106** may include one or more phase converters **110**A, **1106**, and **110**C (hereinafter collectively referred to as phase converters **110**A-**1100**). Although the VR **106** is shown to include three phase converters, use of a VR having less than three or more than three phase converters is also envisioned within the purview of the present disclosure. In some examples, each of the phase converters **110**A-**110**C may be a buck converter. In some other examples, the each of the phase converters **110A-1100** may include a boost converter or a buck-boost converter. In certain other examples, the phase converters **110A-1100** may include any combination of the buck converter, the boost converter, or the buck-boost converter. The phase converters **110A-110C** may include a plurality of electronic switches (e.g., semiconductor switches, not shown), switching of which may be controlled by a VR controller **112** to cause the phase converters **110A-110C** to convert the power received from the power supply into a power suitable for use by the load **104**. In some examples, the phase converters **110A-110C** may supply a power to the load **104** at a reduced voltage in comparison to the predetermined voltage on the input power line.

The VR controller **112** may include electronics to enable switching of the electronic switches in the phase converters **110A-1100**, thereby causing the phase converters **110A-1100** operate. In some examples, the VR controller **112** may include a processing resource and storage medium (see FIGS. **7** and **8**). The storage medium may be configured with instructions, which when executed by the processing resource cause the processing resource to generate control signals for one or more of the phase converters **110A**, **1106**, and **110C**. The control signals may cause enabling or disabling of the phase converters **110A**, **1106**, and **110C** and may control switching of the respective electronic switches in the phase converters **110A**, **1106**, and **110C**. Further, the processing resource that may be used in the VR controller **112** may be a physical device, for example, one or more central processing unit (CPU), one or more semiconductor-based microprocessors, application-specific integrated circuit (ASIC), a field programmable gate array (FPGA), other hardware devices, or combinations thereof, capable of retrieving and executing of the instructions stored in the storage medium. As an alternative or in addition to executing the instructions, the processing resource may include at least one integrated circuit (IC), control logic, electronic circuits, or combinations thereof that include a number of electronic components for performing the functionalities intended to be performed by the VR controller **112**.

As will be understood, variations in a computing demand on the computing system **100** may cause changes in a processing load on the load **104** (e.g., the processing resources) disposed in the computing system **100**. For example, a sudden increase in the computing demand may cause and an increase, e.g., a surge, in the processing load of the processing resources to address the increased computing demand. Consequently, the load **104** may draw more current to operate at high-performance levels to handle the increased processing load. In order to address such increased current demand, in some examples, the VR **106** may include an output capacitor **114** (sometimes, also commonly referred to as "VR output capacitor") through which the load **104** may receive the regulated voltage. In an event of the surge in the current drawn by the processing resources due to increased processing loads thereon, the VR controller **112** may control switching of the electronic switches in the power converters to supply increased current to the load **104**. While the phase converters **110A-1100** and the VR controller **112** may take some time to adapt to the change (e.g., sudden increase) in the current demand from the load **104**, the output capacitor **114** may cater to this increased current demand by quickly discharging an energy stored in the output capacitor **114**. As will be understood, any degradation, lot-to-lot variations, and/or manufacturer-to-manufacturer variations in the capacitance of an output capacitor may lead to situations where a load may be exposed to voltage levels, which do not meet minimum processor requirements. This could lead to any number of undesirable consequences (e.g., malfunctioning, untimely shut-down, operating system crash) in a computing system.

As will be appreciated, in accordance with aspect of the present disclosure, the VR controller **112** in conjunction with the system controller **108** may aid in tracking a characteristic system energy of the computing system **100** and initiating a corrective action to minimize or avoid undesirable consequences of any degradation of the output capacitor **114** or any energy leakage in the load **104**. The energy leakage in the load **104** may be caused due to increase in the parasitic capacitances in the load **104** or degradation of characteristic capacitance of the load **104** or any other loads connected to the load **104**. In some examples, the term "characteristic system energy" as used herein may refer to an energy that is used to charge the output capacitor **114** from a first potential to a second potential higher than the first potential. Further, in some examples, the term "characteristic system energy" as used herein may refer to an energy that the output capacitor **114** releases while being discharged from a third potential to a fourth potential lower than the third potential. Since the output capacitor **114** is coupled with the load **104**, any capacitance associated with the load **104** may also affect the charging and discharging of the output capacitor **114** and hence the characteristic system energy. Accordingly, the characteristic system energy may be related to a capacitance of the output capacitor **114** and the capacitance of the load **104**. More particularly, in some examples, the characteristic system energy may be related to a sum of capacitances comprising the capacitance of the output capacitor **114** and a capacitance of the load **104**. For instance, as the sum of the capacitances of the output capacitor **114** and the load **104** reduces, the characteristic system energy may reduce.

In some examples, the VR controller **112** may determine the characteristic system energy of the computing system **100** on a given power transition event of the computing system **100**. The term "power transition event" as used herein may refer to any of a power-on event or a power-down event of the computing system **100**. The power-on event may be an event when the computing system **100** is powering-on. The power-down event may be an event when the computing system **100** is powering-off. Accordingly, the VR controller **112** may determine the characteristic system energy during the power-on event, the power-down event, or both by measuring a voltage at the output capacitor **114** (hereinafter referred to as "output capacitor voltage") and current flowing via one or more of the phase converters **110A-1100**. Additional details of determining the characteristic system energy is described in conjunction with FIGS. **5** and **6**. Once the characteristic system energy is determined, the VR controller **112** may record the determined characteristic system energy (i.e., a value of the characteristic system energy).

Further, in some examples, in accordance with aspects of the present application, the system controller **108** may track the characteristic system energy of the computing system **100** at the power transition event and determine whether to initiate a corrective action for the computing system **100** based on the characteristic system energy. In some examples, the system controller **108** may be a manageability controller for the computing system **100** and is alternatively referred to as a baseboard management controller (BMC). In certain other examples, the system controller **108** may be a processor-based system separate from the manageability controller and configured to track the characteristic system energy of the computing system **100**. In the description hereinafter, for illustration purposes, the system controller

108 is described as being implemented by the manageability controller, without limiting the scope of the present disclosure. Accordingly, in certain examples, the system controller **108** may be used to implement services for the computing device **100** and may be implemented using a separate processing resource (described below) from a main processing resource (e.g., the load **104**) of the computing device that is used to execute an operating system (OS) for the computing system **100**.

In some examples, the system controller **108** may provide so-called "lights-out" functionality for the computing system **100**. For example, the lights-out functionality may allow a user, such as a system administrator, to perform management operations on the computing system **100** even if the OS is not installed or not functional on the computing system **100**. Moreover, in one example, the system controller **108** may run on an auxiliary power, thus the computing system **100** need not be powered on to an ON-state where control of the computing system **100** is handed over to an operating system after boot. As such, the system controller **108** may provide remote management access (e.g., system console access) regardless of whether the computing system **100** is powered on, whether a primary subsystem hardware of the computing system **100** is functioning, or whether an OS is operating or even installed. In some examples, the system controller **108** may also have management capabilities for sub-systems (e.g., cooling system) of a computing system **100**. Moreover, in certain examples, the system controller **108** may provide so-called "out-of-band" (OOB) services, such as remote console access, remote reboot and power management functionality, monitoring health of the system (e.g., tracking the characteristic system energy), access to system logs, and the like, for the computing system **100**. In some examples, execution of the OOB services by the system controller **108** does not interfere with instructions or workloads running on the main processing resource (e.g., the load **104**) of the computing system **100**.

In some examples, the system controller **108** may include a processing resource **116** and a machine-readable medium **118**. The machine-readable medium **118** may be any electronic, magnetic, optical, or other physical storage device that may store data and/or executable instructions **120**. For example, the machine-readable medium **118** may be a Random Access Memory (RAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), a storage drive, a flash memory, a Compact Disc Read Only Memory (CD-ROM), and the like. The machine-readable medium **118** may be non-transitory. As described in detail herein, the machine-readable medium **118** may be encoded with the executable instructions **120** to perform one or more methods, for example, methods described in FIGS. **2** and **3**. In certain examples, the machine-readable medium **118** may also be encoded with the executable instructions **120** to perform one or more methods, for example, methods described in FIGS. **4** and **5**.

Further, the processing resource **116** may be a physical device, for example, one or more central processing unit (CPU), one or more semiconductor-based microprocessors, an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA), other hardware devices capable of retrieving and executing instructions **120** stored in the machine-readable medium **118**, or combinations thereof. The processing resource **116** may fetch, decode, and execute the instructions **120** stored in the machine-readable medium **118** to track the characteristic system energy and take corrective actions for the computing system **100** based on the characteristic system energy. As an alternative or in addition to executing the instructions **120**, the processing resource **116** may include at least one integrated circuit (IC), control logic, electronic circuits, or combinations thereof that include a number of electronic components for performing the functionalities intended to be performed by the system controller **108** (described further below).

In accordance with aspects of the present disclosure, the processing resource **116** in the system controller **108** may execute one or more of the instructions **120** to retrieve the characteristic system energy of the computing system **100** from the VR **106** (e.g., from the VR controller **112** of the VR **106**). Details of determining the characteristic system energy are described in conjunction with FIGS. **4**, **5**, **6**, and **7**. Further, the processing resource **116** may execute one or more of the instructions **120** to determine whether to initiate a corrective action (e.g., generating an alert, a service/maintenance request, changing an operating mode of the VR) for the VR **106** based on a comparison between the characteristic system energy and a threshold value. For example, the system controller **108** may determine whether the characteristic system energy is lower than the threshold value, and initiate the corrective action for the VR **106** in response to determining that the characteristic system energy is lower than the threshold value. Additional details of the operations of the system controller **108** will be described in conjunction with FIGS. **2** and **3**.

As will be appreciated, the system controller **108**, in accordance with various aspects of the present disclosure, may track the characteristic system energy that is indicative of a health the output capacitor **114** and/or the load **104**. Accordingly, in some examples, the system controller may aid a manufacturer of the computing system **100** to determine the characteristic system energy during production and compare it with a corresponding threshold value during production stage of the computing system. The manufacturer may choose to accept the computing system **100** for shipping to a customer based on the comparison of the characteristic system energy with the corresponding threshold value. In addition, the manufacturer may record such measurement of the characteristic system energy of the computing system during production.

Moreover, the system controller **108** may aid in tracking the characteristic system energy during an operation of the computing system, as well. The characteristic system energy tracked during the operation of the computing system may aid in taking appropriate corrective action, which may include operating the VR **106** in a different mode, generating the service request, generating the alert, and the like. Additionally, the system controller **108** may also analyze a log of the characteristic system energy measurements tracked over a period to determine a trend of the characteristic system energy for the period. Accordingly, the system controller may determine whether any of the output capacitor **114** of the VR **106** or the load **104** is facing any performance issue for which the corrective action may be initiated. Such tracking of the characteristic system energy may aid in facilitating a reliable operation of the computing system **100** and providing appropriate service and maintenance of the computing system **100** in a timely manner.

Further, measurement of the characteristic system energy as performed by the VR controller **112** may not affect normal power-on or power-down sequence of the computing system **100**. Additionally, use of the VR controller **112** to monitor the characteristic system energy obviates need of other test devices and/or electronics to measure the characteristic system energy, thereby reducing cost and complexity of such measurements.

Referring now to FIG. **2**, a flow diagram depicting a method **200** for determining whether to take corrective action for a computing system based on the characteristic system energy is presented, in accordance with an example. In some examples, the method **200** may be performed by the system controller **108** during each power transition event of the computing system **100**. For example, the method **200** may be performed each time when the computing system **100** is powered-on, powered-off, or both. For illustration purposes, the method **200** will be described in conjunction with the computing system **100** of FIG. **1**. The method **200** may include method blocks **202** and **204** that may be performed by a processor-based system, for example, the system controller **108**. In particular, operations at the method blocks **202** and **204** may be performed by the processing resource **116** by executing instructions **120** stored in a machine-readable medium **118**.

At block **202**, the system controller **108** may retrieve the characteristic system energy of the computing system **100** from the VR **106**. As previously noted, the characteristic system energy is related to a sum of capacitances comprising the capacitance of the output capacitor **114** and the capacitance of the load **104**. The characteristic system energy may be determined by the VR controller **112** based on a voltage at the output capacitor **114** and a charging current or a discharging current of the output capacitor **114** via the one or more phase converters. Details of determining the characteristic system energy by the VR controller **112** are described in conjunction with FIGS. **4**, **5**, **6**, and **7**.

Further, at block **204**, the system controller **108** may determine whether to initiate a corrective action for the VR **106** based on a comparison between the characteristic system energy and a threshold value. For instance, the characteristic system energy being lower than the threshold value may be indicative of a condition when the capacitance of the output capacitor **114** has degraded. Such degradation of the capacitance of the output capacitor **114**, if not addressed, may cause various performance and/or reliability issues. To that end, the system controller **108** may determine that the corrective action to address the degradation of the capacitance of the output capacitor **114** needs to be taken based on the comparison between the characteristic system energy and the threshold value. More details on the corrective action taken by the system controller **108** are described in conjunction with FIG. **3**.

Referring now to FIG. **3**, a flow diagram depicting a method **300** for taking corrective action for the computing system **100** based on the characteristic system energy is presented, in accordance with an example. The method **300** may provide certain additional details to the method **200** of FIG. **2**. The method **300** may include method blocks **302**, **304**, **306**, **308**, and **310** that may be performed by a processor-based system, for example, the system controller **108**. In particular, operations at the method blocks **202** and **204** may be performed by the processing resource **116** by executing instructions **120** stored in a machine-readable medium **118**.

At block **302**, the system controller **108** may detect a given power transition event of the computing system **100**. For example, at block **302**, the system controller **108** may detect that the computing system **100** is powered-on and consider such power transition event as a power-on event. In another example, the system controller **108** may detect that the computing system **100** is powered-down (i.e., powered-off) and consider such power transition event as a power-down event. Further, at such power transition event, the VR controller **112** would have also determined and recorded the characteristic system energy of the computing system **100** (see FIGS. **4** and **5**). Accordingly, at block **304**, the system controller **108** may retrieve the characteristic system energy of the computing system **100** from the VR **106**. As previously noted, the characteristic system energy is related to a sum of capacitances comprising the capacitance of the output capacitor **114** and the capacitance of the load **104**.

Further, at block **306**, the system controller **108** may determine whether the characteristic system energy is lower than a threshold value. In some example, the system controller **108** may maintain a mapping of an identity information of the load **104** and corresponding predetermined threshold values. For example, the identity information of the load **104** (e.g., a processor) may include a model number, a product family and/or batch information of the load **104**, or both. Generally, devices having similar model number or belonging to a common product family and/or batch may have some similar electric characteristics, for example, an operating voltage, over all capacitance, and the like. Accordingly, in some examples, the system controller **108** may select the threshold value based on an identity of the load **104**. The system controller **108** may then compare the characteristic system energy obtained from the VR controller **112** with the selected threshold value.

At block **306**, if it is determined that the characteristic system energy is lower than the threshold value, the system controller **108**, at block **308**, may initiate a corrective action. For instance, the characteristic system energy being lower than the threshold value may indicate the output capacitor **114** is degraded (i.e., the capacitance of the capacitor **114** has reduced over a period). In one example, the corrective action may include generating an alert, a service request, or both. In one example, the alert may be displayed on a display (e.g., a monitor) associated with the computing device **100**. In some other examples, the alert may be communicated to a user/administrator of the computing device **100** over a network (e.g., internet, cellular, Wi-Fi, etc.). Further, the service request may be reported to a manufacturer and/or an entity responsible facilitating maintenance and/or services for the computing device **100** (hereinafter referred to as a service entity). Further, in certain other examples, the system controller **108** may instruct the VR controller **112** to operate the VR **106** in a predetermined mode. The predetermined mode may be a predefined safe mode in which the VR controller **112** may change its operating controls for the phase converters **110A-1100** to more aggressively tradeoff performance characteristics, such as efficiency to regulate the output capacitor voltage.

Furthermore, at block **310**, the system controller **108** may store a value of the characteristic system energy. The value of the characteristic system energy may be stored in the machine-readable medium **118** for any later reference or analysis by the system controller **108**. For example, the system controller **108** may create a log of the characteristic system energy retrieved from the VR controller **112** over a period for each power transition event. The log of the characteristic system energy may be stored in the machine-readable medium **118** as a log file for any later reference or analysis by the system controller **108**. In one example, the system controller **108** and/or the service entity may perform a trend analysis of the characteristic system energy tracked over the period. For example, the system controller **108** may determine a trend of the characteristic system energy variation based on the log.

The trend of the characteristic system energy over the period may indicate any of an increase in the characteristic system energy over the period, a decrease in the characteristic system energy over the period, or a steady characteristic system energy. In some examples, the system controller **108** may determine that the output capacitor **114** of the VR **106** has degraded if the trend shows a decline in the value of the characteristic system energy over the period. In particular, if the trend shows the decline, it may be determined that the output capacitor **114** requires less energy (that is increasing over the period) to reach to a certain voltage (e.g., a power-on measurement end threshold voltage, described later) or releases less energy (that may also be increasing over the period) to discharge up-to a particular voltage (e.g., a power-down measurement end threshold voltage, described later). The output capacitor **114** requiring less energy to charge or releasing less energy while discharging may indicate that the output capacitor **114** has degraded. In some examples, the system controller **108** may determine that there exists an issue with the load **104** if the trend shows an incline in a value of the characteristic system energy over a period. Typically, the output capacitor **114** may degrade over a period. However, the incline in the trend may indicate that the load **104** is taking more energy than required and this might be caused due to degradation of inherent capacitances or increase in current and/or energy leakages of the load **104**. Hence, it may be determined that there may be some issue with the load **104**, which may be investigated.

FIG. **4** is a flow diagram depicting a method **400** for monitoring a characteristic system energy, in accordance with an example. The method **400** may represent one example method of monitoring a characteristic system energy during a given power-on event of the computing system **100**. In some examples, the method **400** may be performed by the VR controller **112** during each time the computing system **100** is turned-on. For illustration purposes, the method **400** will be described in conjunction with the computing system **100** of FIG. **1**. The method **400** may include method blocks **402**, **404**, **406**, **408**, **410**, **412**, **414**, **416**, and **418** (hereinafter collectively referred to as blocks **402-418**) some of which may be performed by a processor-based system, for example, the VR controller **112**. In particular, operations at each of the method blocks **404-418** may be performed by a processing resource (not shown in FIGS. **1** and **4**, see FIG. **7**) by executing instructions **306** stored in a machine-readable medium (see FIG. **7**). In the example of FIG. **4**, the VR controller **112** may measure the characteristic system energy as a characteristic system power-on energy for the given power-on event.

At block **402**, the system controller **108** may enable the VR **106** at a given power-on event of the computing system (e.g., when the computing system **100** is turned-on). The system controller **108** may enable the VR **106** by sending a VR turn-on signal to the VR controller **112** of the VR **106**. Further, at block **404**, the VR **106** may initiate providing power-on energy to the load **104** by supplying a charging current to the output capacitor **114** through one or more of phase converters **110A-1100**. In some examples, the VR controller **112** may enable one of the phase converters **110A-1100** (e.g., the phase converter **110A**) to supply the charging current to the output capacitor **114**. In certain other examples, the VR controller **112** may enable a plurality of the phase converters **110A-1100** (e.g., the phase converter **110A**) or all of the phase converters **110A-110C** to supply the charging current to the output capacitor **114**. As will be appreciated, when the charging current is supplied to the output capacitor **114** by only one phase converter (e.g., the phase converter **110A**), a better signal-to-noise ratio may be achieved in measurement of the charging current at blocks **406** and **410** (described later) in comparison to a measurement of charging current supplied by a plurality of the phase converters **110A-1100**.

Further, in certain examples, the VR controller **112** may switch among phase converters of the one or more phase converters **110A-110C** to charge the output capacitor **114**. In other words, the VR controller **112** may alternatingly enable one of the phase converters **110A-110C** to supply the charging current to the output capacitor **114** for subsequent power-on events. For instance, in a given power-on event, if the phase converter **110A** is enabled to charge the output capacitor **114**, in a next power-on event another phase converter **1106** may be enabled to charge the output capacitor **114**. Moreover, in a further next power-on event another phase converter **110C** may be enabled to charge the output capacitor **114**. Such switching among phase converters to charge the output capacitor **114** may enhance a lifetime of the phase converters **110A-1100**.

Furthermore, at block **406**, the VR controller **112** may measure a voltage across the output capacitor **114** (e.g., the output capacitor voltage). The VR controller **112** may measure the output capacitor voltage using one or more voltage sensors (not shown). At block **408**, the VR controller **112** may compare the output capacitor voltage measured at block **406** with a power-on measurement start (POMS) threshold voltage to determine whether the output capacitor voltage is greater than the POMS threshold voltage. The POMS threshold voltage may be a predetermined voltage which when achieved by the output capacitor **114**, the VR controller **112** may initiate measuring the characteristic system energy. In some examples, a value of the POMS threshold voltage may be predefined for a given identity (e.g., a batch, a model number, a product family identity) corresponding the load **104**. In some other examples, the POMS threshold voltage may be customizable by a user/administrator of the computing system **100** at a value lower than the operating voltage of the load **104**. In certain examples, the POMS threshold voltage may be in a range of up-to 15% of an operating voltage of the load **104**. By way of example, if the load **104** is a processor whose operating voltage is 1.5 V, the POMS threshold voltage may be in the range from 0 V to 0.15 V. In some other examples, the POMS threshold voltage may be set to 0 V.

At block **408**, if it is determined that the output capacitor voltage is not greater than or equal to the POMS threshold voltage, the VR controller **112** may continue monitoring the output capacitor voltage as indicated at block **406**. However, at block **408**, if it is determined that the output capacitor voltage is greater than or equal to the POMS threshold voltage, the VR controller **112**, at block **410**, may measure the charging current and the output capacitor voltage. The output capacitor voltage may be measured in a similar fashion as described in conjunction with block **406**. In certain examples, measuring the output capacitor voltage may be optional at block **410**, instead the VR controller **112** may use the output capacitor voltage measured at block **406**, however, the output capacitor voltage measured at block **410** may reflect accurate instantaneous measurement of the output capacitor voltage. Further, the VR controller **112** may measure the charging current from a current feedback signal received from one or more of the phase converters that are supplying the charging currents to the output capacitor **114**. For example, if the phase converter **110A** is enabled to supply the charging current, the phase converter **110A** may send the current feedback signal to the VR controller **112**, wherein the current feedback signal may be indicative of a magnitude of the charging current supplied by the phase converter **110**A.

Moreover, at block **412**, the VR controller **112** may perform another check to determine whether the output capacitor voltage (e.g., measured at block **410**) is less than a power-on measurement end (POME) threshold voltage. The POME threshold voltage may be a predetermined voltage which when achieved by the output capacitor **114**, the VR controller **112** may discontinue measuring the characteristic system energy. In some examples, a value of the POME threshold voltage may be predefined for a given identity (e.g., a batch, a model number, a product family identity) corresponding the load **104**. In some other examples, the POME threshold voltage may be customizable by a user/administrator of the computing system **100**. In certain examples, the POME threshold voltage may be equal to or lower than the operating voltage of the load **104**. By way of example, the POME threshold voltage may be in a range from 60% to 100% of the operating voltage of the load **104**. By way of example, if the load **104** is a processor whose operating voltage is 1.5 V, the POME threshold voltage may be in the range from 0.75 V to 1.5 V. In some other examples, the POME threshold voltage may be set to the operating voltage of the load **104** (e.g., 1.5 V).

At block **412**, if it is determined that the output capacitor voltage is less than the POME threshold voltage, the VR controller **112**, at block **414**, may determine an instantaneous characteristics power-on energy based on the measured charging current and the measured output capacitor voltage. In some examples, the VR controller **112** may determine the instantaneous characteristics power-on energy as a product of the measured charging current, the measured output capacitor voltage, and a time-duration for which the charging current is supplied to the output capacitor **114**. Further, at block **416**, the VR controller **112** may accumulate the instantaneous characteristics power-on energy and may continue to execute the block **410**. As depicted in the flow diagram of FIG. **4**, the VR controller **112** may accumulate the instantaneous characteristics power-on energy until the output capacitor voltage reaches the POME threshold voltage.

Further, at block **412**, if it is determined that the output capacitor voltage is not less than the POME threshold voltage, the VR controller **112**, at block **418**, may store the accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy corresponding to the given power-on event of the computing system **100**. The VR controller **112** may store the accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy in a machine-readable medium associated with the VR controller **112**. For the given power-on event, the characteristic system power-on energy may represent the characteristic system energy.

FIG. **5** is a flow diagram depicting a method **500** for monitoring a characteristic system energy, in accordance with an example. The method **500** may represent one example method of monitoring a characteristic system energy during a given power-down event of the computing system **100**. In some examples, the method **500** may be performed by the VR controller **112** during each time the computing system **100** is powered-off. For illustration purposes, the method **500** will be described in conjunction with the computing system **100** of FIG. **1**. The method **500** may include method blocks **502**, **504**, **506**, **508**, **510**, **512**, **514**, **516**, **518**, and **520** (hereinafter collectively referred to as blocks **502-520**) which may be performed by a processor-based system, for example, the VR controller **112**. In particular, operations at each of the method blocks **502-520** may be performed by a processing resource (not shown in FIGS. **1** and **5**, see FIG. **8**) by executing instructions **306** stored in a machine-readable medium (see FIG. **8**). In the example of FIG. **5**, the VR controller **112** may measure the characteristic system energy as a characteristic system power-down energy for the given power-down event.

At block **502**, the VR controller **112** may disable the one or more phase converters **110**A-**110**C of the VR **106** at the given power-down event of the computing system **100** (e.g., when the computing system **100** is powered-off). In particular, in some examples, all of the phase converters **110**A-**110**C may be disabled. The VR controller **112** may disable the phase converters **110**A-**110**C by discontinuing sending control signals to the phase converters **110**A-**110**C. Further, at block **504**, the VR controller **112** may enable at least one phase converter of the one or more phase converters **110**A-**110**C to discharge the output capacitor **114** by allowing a passage of a discharging current of the output capacitor **114** via the at least one phase converter. In some examples, the VR controller **112** may enable one of the phase converters **110**A-**110**C (e.g., the phase converter **110**A) to discharge to the output capacitor **114**. In certain other examples, the VR controller **112** may enable a plurality of the phase converters **110**A-**1100** (e.g., the phase converter **110**A) or all of the phase converters **110**A-**110**C to discharge the output capacitor **114**. As will be appreciated, when the output capacitor **114** is discharged via only one phase converter (e.g., the phase converter **110**A), a better signal-to-noise ratio may be achieved in measurement of the discharging current at blocks **506** and **510** (described later) in comparison to a measurement of discharging current supplied by the plurality of the phase converters **110**A-**110**C. Further, in some example, the VR controller **112** may switch among phase converters of the one or more phase converters **110**A-**1100** to discharge the output capacitor **114** for different power-down events, in a similar fashion as described in FIG. **4**. Such switching among phase converters to discharge the output capacitor **114** may enhance the lifetime of the phase converters **110**A-**110**C.

Further, at block **506**, the VR controller **112** may measure the output capacitor voltage. Furthermore, at block **508**, the VR controller **112** may compare the output capacitor voltage with a power-down measurement start (PDMS) threshold voltage to determine whether the output capacitor voltage is lower than the PDMS threshold voltage. The PDMS threshold voltage may be a predetermined voltage which when achieved by the output capacitor **114**, the VR controller **112** may initiate measuring the characteristic system energy. In some examples, a value of the PDMS threshold voltage may be predefined for a given identity (e.g., a batch, a model number, a product family identity) corresponding the load **104**. In some other examples, the PDMS threshold voltage may be customizable by a user/administrator of the computing system **100**. In certain examples, the PDMS threshold voltage may be equal to or lower than the operating voltage of the load **104**. By way of example, the PDMS threshold voltage may be in a range from 60% to 100% of the operating voltage of the load **104**. By way of example, if the load **104** is a processor whose operating voltage is 1.5 V, the PDMS threshold voltage may be in the range from 0.75 V to 1.5 V. In some other examples, the PDMS threshold voltage may be set to the operating voltage of the load **104** (e.g., 1.5 V). In some examples, the PDMS threshold voltage may be similar to the POME threshold voltage.

At block **508**, if it is determined that the output capacitor voltage is not lower than or equal to the PDMS threshold voltage, the VR controller **112** may continue monitoring the output capacitor voltage as indicated at block **506**. However, at block **508**, if it is determined that the output capacitor voltage is lower than the PDMS threshold voltage, the VR controller **112**, at block **510**, may measure the discharging current of the output capacitor **114** and the output capacitor voltage. The output capacitor voltage may be measured in a similar fashion as described in conjunction with block **506**. In certain examples, measuring the output capacitor voltage may be optional at block **510**, instead the VR controller **112** may use the output capacitor voltage measured at block **506**, however, the output capacitor voltage measured at block **410** may reflect accurate instantaneous measurement of the output capacitor voltage. The VR controller **112** may measure the discharging current from a current feedback signal received from one or more of the phase converters that are enabled for discharging the output capacitor **114**. For example, if the phase converter **110**A is enabled to supply the charging current, the phase converter **110**A may send the current feedback signal to the VR controller **112**, wherein the current feedback signal may be indicative of a magnitude of the discharging current passing through the phase converter **110**A.

Moreover, at block **512**, the VR controller **112** may perform another check to determine whether the output capacitor voltage (e.g., measured at block **510**) is greater than or equal to a power-down measurement end (PDME) threshold voltage. The PDME threshold voltage may be a predetermined voltage which when achieved by the output capacitor **114**, the VR controller **112** may discontinue measuring the characteristic system energy. In some examples, a value of the PDME threshold voltage may be predefined for a given identity (e.g., a batch, a model number, a product family identity) corresponding the load **104**. In some other examples, the PDME threshold voltage may be customizable by a user/administrator of the computing system **100**. In certain examples, the PDME threshold voltage may be in a range of up-to 15% of an operating voltage of the load **104**. By way of example, if the load **104** is a processor whose operating voltage is 1.5 V, the PDME threshold voltage may be in the range of 0 to 0.15 V. In some other examples, the PDME threshold voltage may be set to 0 V. In some examples, the PDME threshold voltage may be similar to the POMS threshold voltage.

At block **512**, if it is determined that the output capacitor voltage is greater than or equal to the PDME threshold voltage, the VR controller **112**, at block **514**, may determine an instantaneous characteristics power-down energy based on the measured charging current and the measured output capacitor voltage. In some examples, the VR controller **112** may determine the instantaneous characteristics power-down energy as a product of the measured discharging current, the measured output capacitor voltage, and a time-duration for which the discharging current is supplied from the output capacitor **114**. Further, at block **516**, the VR controller **112** may accumulate the instantaneous characteristics power-down energy and may continue to execute the block **510**. As depicted in the flow diagram of FIG. **5**, the VR controller **112** may accumulate the instantaneous characteristics power-down energy until the output capacitor voltage reaches the PDME threshold voltage.

Further, at block **512**, if it is determined that the output capacitor voltage is lower than the PDME threshold voltage, the VR controller **112**, at block **518**, may store the accumulated instantaneous characteristics power-down energy as the characteristic system power-down energy corresponding to the given power-down event of the computing system **100** a machine-readable medium associated with the VR controller **112**. For the given power-down event, the characteristic system power-down energy may represent the characteristic system energy. Moreover, at block **520**, the VR controller **112** may enable the rest of the one or more phase converters (i.e., phase converters of the phase converters **110A-1100** other than the one(s) enabled at block **504**) to allow the flow of the discharging current.

Moving to FIG. **6**, a block diagram **600** depicting a processing resource **602** and a machine-readable medium **604** encoded with example instructions to determine whether to take a corrective action for the computing system **100**. The machine-readable medium **604** may be non-transitory and is alternatively referred to as a non-transitory machine-readable medium **604**. In some examples, the machine-readable medium **604** may be accessed by the processing resource **602**. In some examples, the processing resource **602** may represent one example of the processing resource **116** of the system controller **108**. Further, the machine-readable medium **604** may represent one example of the machine-readable medium **118** of the system controller **108**.

The machine-readable medium **604** may be any electronic, magnetic, optical, or other physical storage device that may store data and/or executable instructions. Therefore, the machine-readable medium **604** may be, for example, RAM, an EEPROM, a storage drive, a flash memory, a CD-ROM, and the like. As described in detail herein, the machine-readable medium **604** may be encoded with executable instructions **606** and **608** for performing the method **200** described in FIG. **2**. Although not shown, in some examples, the machine-readable medium **604** may be encoded with certain additional executable instructions to perform the method **300** of FIG. **3**, the method **400** of FIG. **4**, the method **500** of FIG. **5**, and/or any other operations performed by the system controller **108**, without limiting the scope of the present disclosure.

The processing resource **602** may be a physical device, for example, one or more CPU, one or more semiconductor-based microprocessor, one or more GPU, ASIC, FPGA, other hardware devices capable of retrieving and executing the instructions **606**, **608** stored in the machine-readable medium **604**, or combinations thereof. In some examples, the processing resource **602** may fetch, decode, and execute the instructions **606**, **608** stored in the machine-readable medium **604** to determine whether to take corrective action for the computing system **100**. In certain examples, as an alternative or in addition to retrieving and executing the instructions **606**, **608**, the processing resource **602** may include at least one IC, other control logic, other electronic circuits, or combinations thereof that include a number of electronic components for performing the functionalities intended to be performed by the system controller **108** of FIG. **1**.

The instructions **606** when executed by the processing resource **602** may cause the processing resource **602** to retrieve a characteristic system energy of the computing system **100** from the VR **106**. The characteristic system energy may be related to a sum of capacitances comprising a capacitance of the output capacitor and a capacitance of the load **104** and is determined by the VR controller **112** based on the output capacitor voltage and the charging current or the discharging current of the output capacitor **114** via the one or more phase converters **110A-1100**. Further, the instructions **608** when executed by the processing resource

602 may cause the processing resource **602** to determine whether to initiate a corrective action (e.g., generating an alert, a service/maintenance request, changing an operating mode of the VR) for the VR **106** based on a comparison between the characteristic system energy and a threshold value.

Although not shown in FIG. **6**, in some examples, the machine-readable medium **604** may also include additional instructions which when executed by the processing resource **602** to select the threshold value based on an identity of the load **104**; determine whether the characteristic system energy is lower than the threshold value; and initiate the corrective action in response to determining that the characteristic system energy is lower than the threshold value. Further, in certain examples, the machine-readable medium **604** may also include additional instructions which when executed by the processing resource **602** to create a log of the characteristic system energy retrieved from the VR controller **112** the over a period and determine a trend of the characteristic system energy variation based on the log. Furthermore, in certain examples, the machine-readable medium **604** may also include additional instructions which when executed by the processing resource **602** to determine that there exists an issue with the load **104** if the trend shows an incline in the characteristic system energy over the period. Additionally, in some examples, the machine-readable medium **604** may also include additional instructions which when executed by the processing resource **602** to determine that the output capacitor **114** of the VR **106** has degraded if the trend shows a decline in the characteristic system energy over the period.

Referring now to FIG. **7**, a block diagram **700** depicting a processing resource **702** and a machine-readable medium **704** encoded with example instructions to monitor a characteristic system energy, in accordance with an example. The block diagram **700** may represent the VR controller **112**, in one example. The processing resource **702** and a machine-readable medium **704** of FIG. **7** are similar in many aspects (e.g., types and structural details) with the processing resource **602** and the machine-readable medium **604** of FIG. **6**, details of which are not repeated herein. The machine-readable medium **704** may store instructions **706**, **708**, **710**, **712**, and **714** that may be accessed and executed by the processing resource **702**.

The instructions **706** when executed by the processing resource **702** may cause the processing resource **702** to provide a power-on energy to the load **104** by supplying a charging current to the output capacitor **114** through the one or more of the phase converters **110A-1100**. Further, the instructions **708** when executed by the processing resource **702** may cause the processing resource **702** to measure response to determining that the output capacitor voltage is greater than or equal to the POMS threshold voltage, the charging current and the output capacitor voltage. Furthermore, the instructions **710** when executed by the processing resource **702** may cause the processing resource **702** to determine an instantaneous characteristics power-on energy based on the measured charging current and the measured output capacitor voltage. Moreover, the instructions **712** when executed by the processing resource **702** may cause the processing resource **702** to accumulate the instantaneous characteristics power-on energy until the output capacitor voltage attains the POME threshold voltage. Additionally, the instructions **714** when executed by the processing resource **702** may cause the processing resource **702** to store the accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy corresponding to the given power-on event of the computing system **100**. The accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy in the machine-readable medium **704**.

Referring now to FIG. **8**, a block diagram **800** depicting a processing resource **802** and a machine-readable medium **804** encoded with example instructions to monitor a characteristic system energy, in accordance with an example. The block diagram **800** may represent the VR controller **112**, in one example. The processing resource **802** and a machine-readable medium **804** of FIG. **8** are similar in many aspects (e.g., types and structural details) with the processing resource **602** and the machine-readable medium **604** of FIG. **6**, details of which are not repeated herein. The machine-readable medium **804** may store instructions **806**, **808**, **810**, **812**, **814**, **816**, and **818** that may be accessed and executed by the processing resource **802**.

The instructions **806** when executed by the processing resource **802** may cause the processing resource **802** to disable the one or more phase converters **110A-1100**. Further, the instructions **808** when executed by the processing resource **802** may cause the processing resource **802** to enable at least one phase converter of the one or more phase converters **110A-110C** to discharge the output capacitor **114** by allowing a passage of a discharging current via the at least one phase converter. The instructions **810** when executed by the processing resource **802** may cause the processing resource **802** to measure the discharging current and the output capacitor voltage, in response to determining that the output capacitor voltage is lower than or equal to the PDMS threshold voltage.

Furthermore, the instructions **812** when executed by the processing resource **802** may cause the processing resource **802** to determine an instantaneous characteristics power-down energy based on the measured discharging current and the measured output capacitor voltage. Moreover, the instructions **814** when executed by the processing resource **802** may cause the processing resource **802** to accumulate the instantaneous characteristics power-down energy until the output capacitor voltage attains the PDME threshold voltage. The instructions **816** when executed by the processing resource **802** may cause the processing resource **802** to store the accumulated instantaneous characteristics power-down energy as the characteristic system power-down energy corresponding to the given power-down event of the computing system **100**. Additionally, the instructions **818** when executed by the processing resource **802** may cause the processing resource **802** to enable rest of the one or more phase converters **110A-110C** to allow the flow of the discharging current.

While certain implementations have been shown and described above, various changes in form and details may be made. For example, some features and/or functions that have been described in relation to one implementation and/or process may be related to other implementations. In other words, processes, features, components, and/or properties described in relation to one implementation may be useful in other implementations. Furthermore, it should be appreciated that the systems and methods described herein may include various combinations and/or sub-combinations of the components and/or features of the different implementations described.

In the foregoing description, numerous details are set forth to provide an understanding of the subject matter disclosed herein. However, implementation may be practiced without some or all of these details. Other implementations may include modifications, combinations, and variations from the details discussed above. It is intended that the following claims cover such modifications and variations.

What is claimed is:

1. A system controller fora computing system, comprising:

a machine-readable medium for storing executable instructions;

a processing resource coupled to the machine-readable medium, wherein the processing resource executes the instructions to:

retrieve a characteristic system energy of the computing system from a voltage regulator (VR) comprising a VR controller, one or more phase converters, and an output capacitor coupled to a load to provide an operating voltage to the load, wherein the characteristic system energy is related to a sum of capacitances comprising a capacitance of the output capacitor and a capacitance of the load and is determined by the VR controller based on a voltage at the output capacitor and a charging current or a discharging current of the output capacitor via the one or more phase converters; and

determine whether to initiate a corrective action for the VR based on a comparison between the characteristic system energy and a threshold value.

2. The system controller of claim **1**, wherein the computing system is a server, a storage system, a computer system, or an edge-computing device.

3. The system controller of claim **1**, wherein the load comprises a compute resource.

4. The system controller of claim **1**, wherein the processing resource executes the instructions to select the threshold value based on an identity of the load.

5. The system controller of claim **1**, wherein the processing resource executes the instructions to:

determine whether the characteristic system energy is lower than the threshold value; and

initiate the corrective action in response to determining that the characteristic system energy is lower than the threshold value.

6. The system controller of claim **1**, wherein processing resource executes the instructions to generate an alert, a service request, or both, as the corrective action.

7. The system controller of claim **1**, wherein processing resource executes the instructions to operate the VR in a predefined safe mode, as the corrective action, to continue supply of power to the load from the VR.

8. The system controller of claim **1**, wherein the processing resource executes the instructions to retrieve the characteristic system energy from the VR controller upon a given power transition event of the computing system.

9. The system controller of claim **8**, wherein the given power transition event is a given power-on event of the computing system, wherein the characteristic system energy is a characteristic system power-on energy measured by the VR controller during the given power-on event of the computing system, and wherein the VR controller is to:

provide a power-on energy to the load by supplying the charging current to the output capacitor through the one or more of the phase converters;

measure the charging current and the voltage at the output capacitor;

determine an instantaneous characteristics power-on energy based on the measured charging current and the measured voltage;

accumulate the instantaneous characteristics power-on energy until the measured voltage attains a power-on measurement end (POME) threshold voltage; and

store the accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy corresponding to the given power-on event of the computing system.

10. The system controller of claim **9**, wherein the VR controller is to switch among phase converters of the one or more phase converters to charge the output capacitor.

11. The system controller of claim **9**, wherein the VR controller is to initiate the determination of the instantaneous characteristics power-on energy and the accumulation of the instantaneous characteristics power-on energy after the measured voltage attains a power-on measurement start (POMS) threshold voltage that is lower than the POME threshold voltage.

12. The system controller of claim **8**, wherein the given power transition event is a given power-down event of the computing system, wherein the characteristic system energy is a characteristic system power-down energy measured by the VR controller during the given power-down event of the computing system, and wherein the VR controller is to:

disable the one or more phase converters;

enable at least one phase converter of the one or more phase converters to discharge the output capacitor by allowing a passage of the discharging current via the at least one phase converter;

measure, in response to determining that the voltage of the output capacitor is lower than or equal to a power-down measurement start (PDMS) threshold voltage, the discharging current and the voltage at the output capacitor;

determine an instantaneous characteristics power-down energy based on the measured discharging current and the measured voltage;

accumulate the instantaneous characteristics power-down energy until the measured voltage attains a power-down measurement end (PDME) threshold voltage that is lower than the PDMS threshold voltage;

store the accumulated instantaneous characteristics power-down energy as the characteristic system power-down energy corresponding to the given power-down event of the computing system; and

enable rest of the one or more phase converters to allow the flow of the discharging current.

13. The system controller of claim **1**, wherein the processing resource executes the instructions to:

create a log of the characteristic system energy retrieved from the VR controller the over a period;

determine a trend of the characteristic system energy variation based on the log;

determine that there exists an issue with the load if the trend shows an incline in a value of the characteristic system energy over a period; and

determine that the output capacitor of the VR has degraded if the trend shows a decline in the value of the characteristic system energy over the period.

14. A non-transitory machine-readable medium storing instructions executable by a processing resource, the instructions comprising:

instructions to retrieve a characteristic system energy of the computing system from a voltage regulator (VR) comprising a VR controller, one or more phase converters, and an output capacitor coupled to a load to provide an operating voltage to the load, wherein the characteristic system energy is determined by the VR controller based on a voltage at the output capacitor and a charging current or a discharging current of the output capacitor via the one or more phase converters; and

instructions to determine whether to initiate a corrective action for the VR based on a comparison between the characteristic system energy and a threshold value.

15. The non-transitory machine-readable medium of claim **14**, further comprising:

instructions to determine whether the characteristic system energy is lower than the threshold value; and

instructions to initiate the corrective action for the VR in response to determining that the characteristic system energy is lower than the threshold value.

16. The non-transitory machine-readable medium of claim **14**, further comprising instructions to create a log of the characteristic system energy retrieved from the VR controller the over a period.

17. The non-transitory machine-readable medium of claim **16**, further comprising:

instructions to determine a trend of the characteristic system energy variation based on the log;

instructions to determine that there exists an issue with the load if the trend shows an incline in the characteristic system energy over the period; and

instructions to determine that the output capacitor of the VR has degraded if the trend shows a decline in the characteristic system energy over the period.

18. A method comprising:

retrieving, by a system controller, a characteristic system energy of the computing system from a voltage regulator (VR) comprising a VR controller, one or more phase converters, and an output capacitor coupled to a load to provide an operating voltage to the load, wherein the characteristic system energy is related to a sum of capacitances comprising a capacitance of the output capacitor and a capacitance of the load and is determined by the VR controller based on a voltage at the output capacitor and a charging current or a discharging current of the output capacitor via the one or more phase converters;

determining, by the system controller, whether to initiate a corrective action for the VR based on a comparison between the characteristic system energy and a threshold value.

19. The method of claim **18**, wherein the characteristic system energy is a characteristic system power-on energy measured by the VR controller during a given power-on event of the computing system, and wherein the method further comprising:

providing a power-on energy to the load by supplying the charging current to the output capacitor through the one or more of the phase converters;

measuring, in response to determining that the voltage of the output capacitor is greater than or equal to a power-on measurement start (POMS) threshold voltage, the charging current and the voltage at the output capacitor;

determining an instantaneous characteristics power-on energy based on the measured current and the measured voltage; and

accumulating the instantaneous characteristics power-on energy until the measured voltage attains a power-on measurement end (POME) threshold voltage; and

storing the accumulated instantaneous characteristics power-on energy as the characteristic system power-on energy corresponding to the given power-on event of the computing system.

20. The method of claim **18**, wherein the characteristic system energy is a characteristic system power-down energy measured by the VR controller during a given power-down event of the computing system, and wherein the method further comprising:

disabling the one or more phase converters;

enabling at least one phase converter of the one or more phase converters to discharge the output capacitor by allowing a passage of the discharging current via the at least one phase converter;

measuring, in response to determining that the voltage of the output capacitor is lower than or equal to a power-down measurement start (PDMS) threshold voltage, the discharging current and the voltage at the output capacitor;

determining an instantaneous characteristics power-down energy based on the measured discharging current and the measured voltage;

accumulating the instantaneous characteristics power-down energy until the measured voltage attains a power-down measurement end (PDME) threshold voltage that is lower than the PDMS threshold voltage;

storing the accumulated instantaneous characteristics power-down energy as the characteristic system power-down energy corresponding to the given power-down event of the computing system; and

enabling rest of the one or more phase converters to allow the flow of the discharging current.

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